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# Coastline Extraction Using RTK GPS/GLONASS Combination Method

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**KEY WORDS:** Coastline extraction, Digital map, Real time kinematic, Global positioning system/Global navigation satellite system, High wave of scar, Tide

**ABSTRACT:** *On this study, realtime GPS technique and combination of GPS/GLONASS technique are used to extracting coastline. The object of coastline is Gwanganri beach located in Busan. The coastline is observed along the traces of coastline when high wave of scar by using digital map of 1:1,000 and at random time zone, coastline is surveyed along the boundary line that is contacting with sea water level. When the coastline of random time zone is converted by height of tide table, the coastline when high wave of scar and converted coastline are shown as coincident approximately.*

## 1. Introduction

The efficient management and use of the coastlines is an important issue for the use of national lands, and to protect the sea resources. The main issues associated with managing or using coastlines are safety and recovery of coastal areas, environment, managing resources, nationalplans for using lands, industrial development, traffic and governmental policies. However, coastal areas have strong localities, and each coastal area has its own special issues (Yang, 2000).

The functions of having precise and consistent information are outlined below. First, it can provide important data to the public. Second, it improves digital coastal charts for navigation. Third, it provides exact boundary data for simulation of storm surge and overflow near the shore. Fourth, it provides detailed numbers for managing resources near the shore. Fifth, improves management of shores using an improved land-sea geographic information system. Sixth, it provides exact analysis of environmental problems (Kim & Choi, 2005). For these purposes, it is necessary to provide quantitative data of coastlines, including their longitudes and latitudes. However, there is a large difference between real-time GPS/GLONASS and recent digital maps. The digital maps require so much time to produce. This makes it difficult to reflect ever changing coastline data. However, the GPS/GLONASS method can complement this shortcoming.

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In this research, coastlines were surveyed during high water (high wave of scar), using RTK GPS/GLONASS andduring other randomly selected points of time, and then the changed amount of coastlines in the two data were compared. Coastline extraction, using RTK GPS/GLONASS was suggested as the preferred method, compared to others, such as extracting the amount changed using height of the tide.

## 2. The Theories of Surveying Coastline

Surveying coastlines is a process used to make a map by checking shapes and kinds of coastlines. Surveyed items include: land terrain near coastlines and rock that is sometimes covered by water; coastlines and near terrains are surveyed using photogrammetry, and some times using actual measurement if necessary (Yeu, 1995; Lee & Kum, 1996; Park, 2001).

In this research, coastlines were surveyed using RTK GPS/GLONASS, extracting coastline using aerial photogrammetry. If a riverside line obtained by photogrammetry corresponds to its definition, there are no problems at all. However, a riverside line is always changing, due to changing sea levels by tides, making the relationship between a riverside line from photogrammetry and that to be drawn on the map more difficult (Jang et al., 2003).

The smaller the slope of a riverside line, the larger its change will be. If pictures are taken during a full tide, the riverside line pictures can be used with modification. However, for pictures taken during other tides, the slope of coast terrain should be compensated by considering the time when the pictures were taken and the tides.

Furthermore, if a coast is mostly composed of rocks, its terrain is not largely changing. However, in the cases of sandy coastlines, it is changing dramatically, due to waves and winds.

Therefore, when analyzing aerial pictures to determine coastlines, the factors below should be considered, in addition to those described, previously.

1. Artificial coast facilities, such as harbors and breakwaters, are included in coastlines, without modification.
2. When pictures are taken during Approx. H. H. W, the boundary between sea and land becomes a coastline.
3. When coastlines are composed of rocks or sand on a gentle slope, the high wave of scar becomes coastlines.
4. When there is no high wave of scar, height of tide during Figure 1 measures, and differences of tide($\ell$) of higher high water are obtained from the tide tableof the coasts, then the vertical average slope (Θ) and complement(s) are obtained from the formula below.

$$S = l \times cot\theta$$

$$\theta = \tan^{-1}\left(\frac{h}{d}\right) \qquad (1)$$

5. In the case of aerial (1/1,000~1/5,000), in put the height of Approx. H. H. W, based on control points in pictures, and then determines the height of coastlines in the same manner as a contour line drawing.
6. Natural colors or infrared pictures are helpful in analyzing pictures.
7. If pictures are taken during low tides, it is easy to discover the low water line, deadlocks, rock that covers and uncovers, and sandbanks.

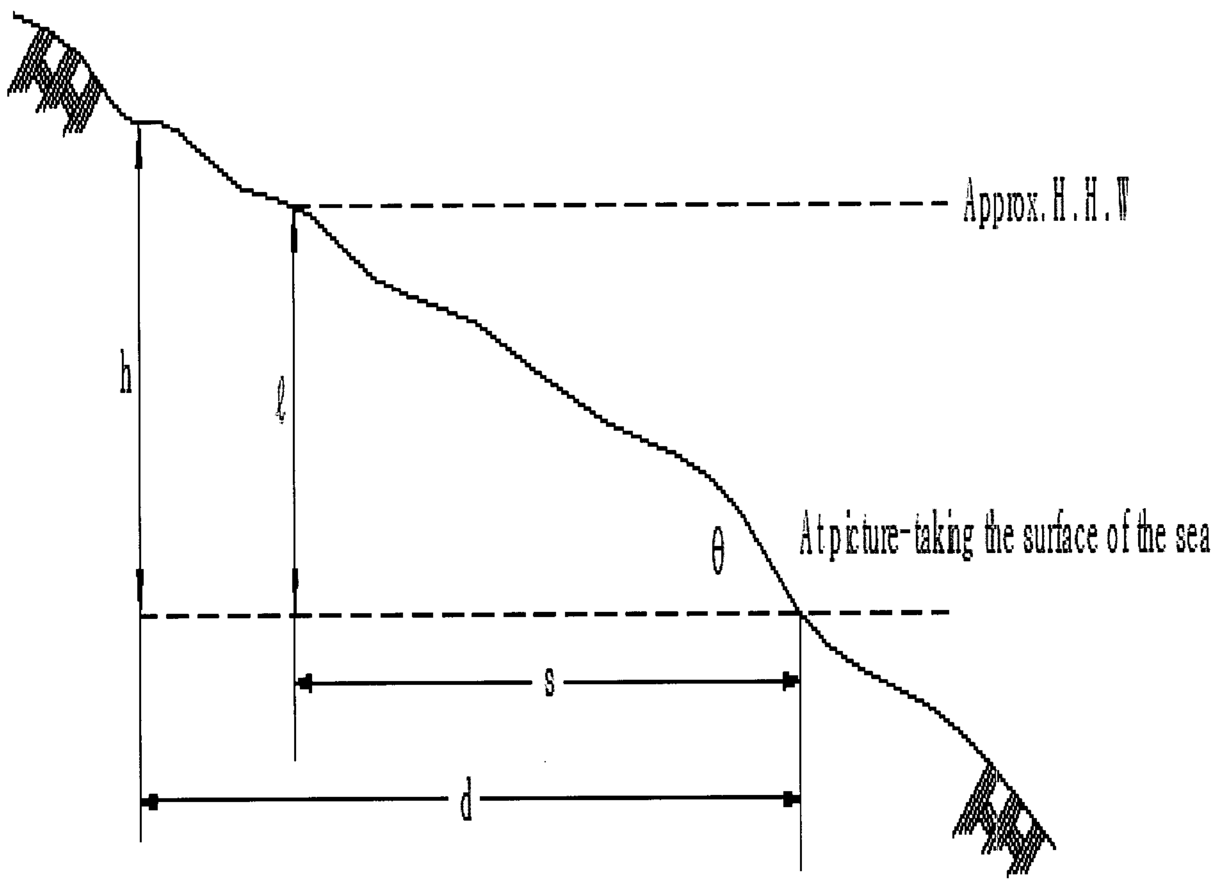


**Fig. 1** Deciding coastline by calibration differences of tide

**Table 1** Analysis of surveying standard of each law

| Law | | Law of surveying No.5 | Law of hydrographic work No.4 |
|---|---|---|---|
| The size of earth | | Bessel | Bessel (and for WGS-84) |
| Position | | Longitude and latitude (with right angle and polar coordinates) | Longitude and latitude (with right angle and polar coordinates) |
| Base point for surveying | | The starting point of Korea for Longitude and latitude | The starting point of Korea for Longitude and latitude |
| Height Depth | Altitude | The starting point of Korea Depth from the mean sea level | The starting point of Korea Depth from the mean sea level |
| | Depth | NA | Depth from the datum level |
| | Coastline | Line or riverside line with mean sea level 0m | The boundary between sea land during approximate highest high water |
| | Hehght of artificial Facility such as bridges | Mean sea level | Approximate highest high water |
| Usage | | Making land map | Making sea map |

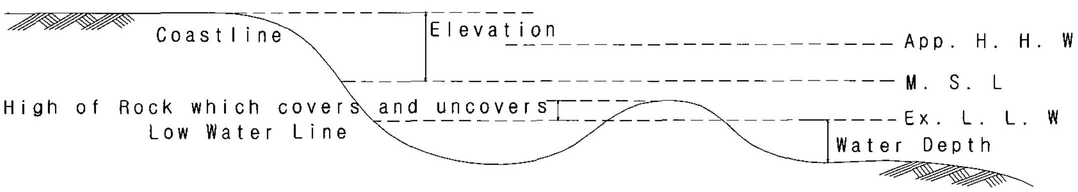


**Fig. 2** Coastline and water depth

## 3. Observation

### 3.1 The observation area

The observation area, in this research, a bathing resort at Gwanganri beach in Pusan, Korea, which is located at the west side of Haeundae beach, is composed of 82,000㎡of total area, length of 1.4km, width of 64m, and high-quality sands.control points used in this research are those used in the construction of the Kwangan Grand Bridge, as shown in Table 2. To show the boundary of the coastline by using real time GPS/GLONASS, the coastline was surveyed along high wave of scar during approx. higher high water,
using the digital map, and coastlines during randomly selected times were also surveyed. The coastlines, determined by using approx. higher high water, and the randomly surveyed coastlines were compared after being converted, using the tide table. The tide survey used in this research came from the tide station located at latitude 35°06′ and longitude 129°02′ (Table 3).

### 3.2 The specification of survey devices and survey methods

The receiver used was L1/L2, C/A-code, P-code and JAVAD with 20 channels, and A Legant was used as an antenna. Table 4 shows the specifications of the survey devices.

Firstly, the target area was initialized, using 3 points (Table 2),

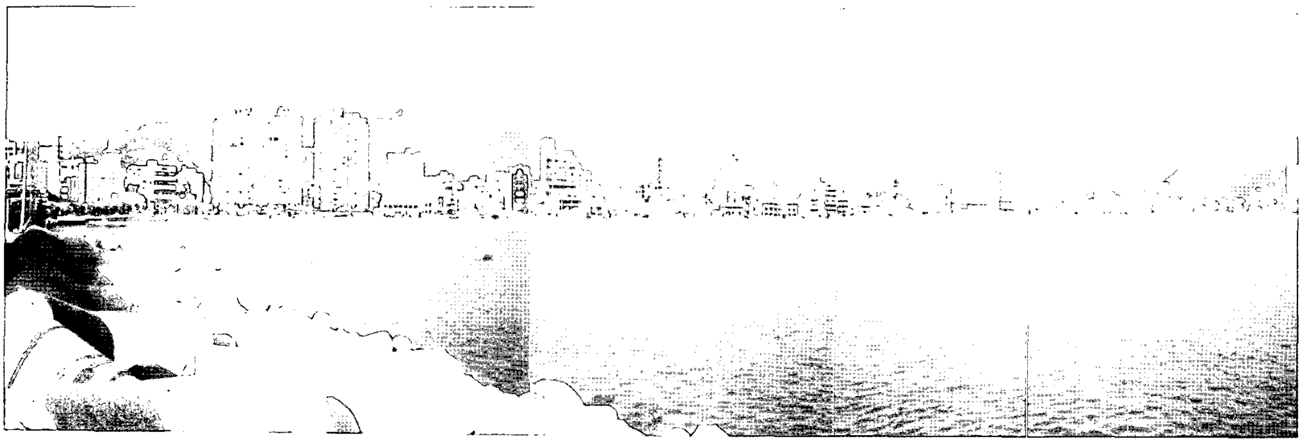

Fig. 3 The observation area

**Table 2** GPS/GLONASS control point

| Point | X Coordinate(m) | Y Coordinate(m) | Hight(m) |
|---|---|---|---|
| 1 | 182320.447 | 210657.837 | 4.7643 |
| 2 | 182993.645 | 210669.659 | 4.7896 |
| 3 | 183756.310 | 211281.373 | 4.1737 |

**Table 3** Tide data from the tide station of Busan

| | | | |
|---|---|---|---|
| Tide station | Latitude : 35°06 ′<br>Longitude : 129°02 ′ | App.H.H.W | 361.6cm |
| Sp.Rise | 123.8cm | Np.Rise | 86.0cm |
| M.S.L | 64.9cm | M.H.W.I | 8h 2m |
| Ex.H.H.W | 168cm(1960.8.22) | Ex.L.L.W | -41cm(1967.2.26~1968.2.16) |

**Table 4** The specification of surveying devices

| Tracking specification | | | Performance specification | |
|---|---|---|---|---|
| Tracking | Signals tracked | Measure mode | RTK mode | |
| | | | H | V |
| 40 L1 channels, 20 L1+L2 channels GPS/GLO (optional) | L1/L2 (L1-C/A &L1/L2 Full Cycle Carrier, P1/P2) | Static Kinematic RTK DGPS | 10mm+1.5ppm (×Base) for 2 freq. | 20mm+1.5ppm (×Base) for 2 freq. |

which were used as control points near the coastline, and surveyed along high wave of scar in regular steps. Lastly, the coastline was surveyed for randomly selected height of the tide.

## 4. The Results and Analysis of the Surveying

The coastline was surveyed during approximate highest high water, using RTK GPS/GLONASS, as shown in Figure 4, and then the horizontal length was shown in vertical to the coastline. From the horizontal length, and the difference between these two heights of the tides, the slope of coast was calculated. Table 6 shows the data associated with changes in the length of the coastline due to tides.

The horizontal length, randomly surveyed based on the coastline during a full tide, was compared to the changed coastline. The tolerance was based on a positioning error for each reduced scale, published by the National Geography Institute, as shown in Table 5. As shown in Figure 5, 30 reference lines, the sample data, were set in a regular length, based on roads and commercial buildings near the coast (Kim, 2000).

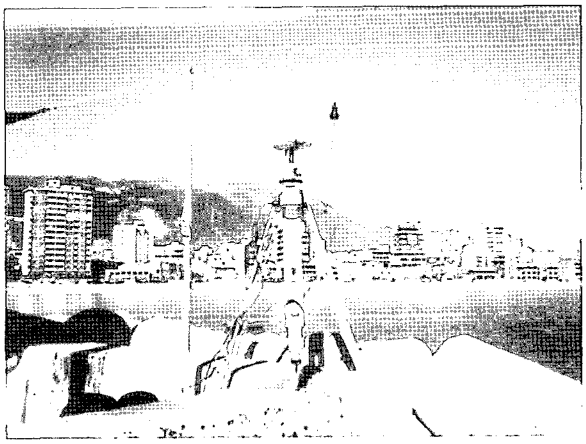

**Fig. 4** GPS/GLONASS receiver installed at control points

**Table 5** Positioning tolerance error for reduced scale (NGI, 1988)

| Reduced scale | Positioning error of plane | Positioning error of elevation |
|---|---|---|
| 1 : 500 | within ± 0.25m | within ± 0.25m |
| 1 : 1,000 | within ± 0.70m | within ± 0.33m |
| 1 : 2,500 | within ± 1.75m | within ± 0.66m |
| 1 : 5,000 | within ± 3.50m | within ± 1.66m |
| 1 : 10,000 | within ± 7.00m | within ± 3.33m |

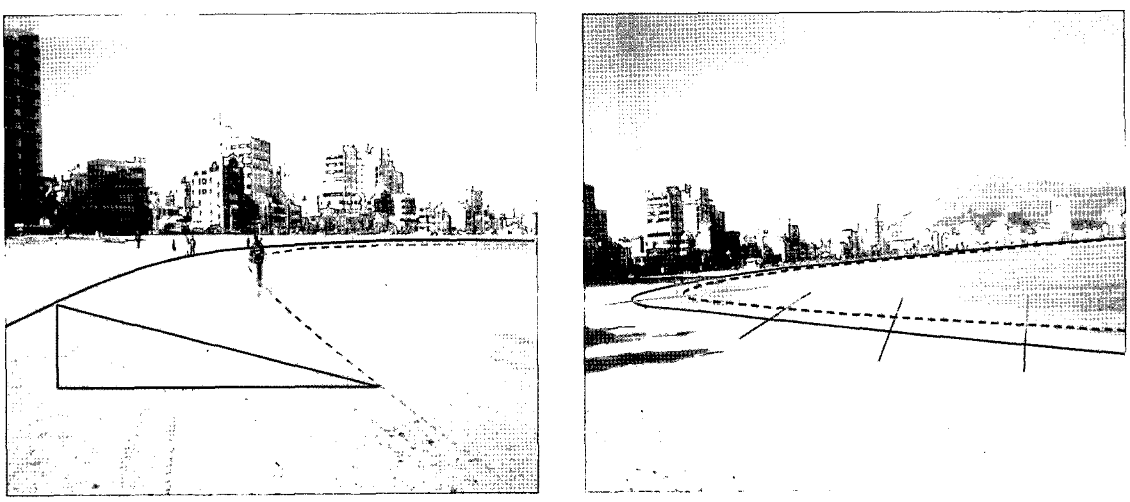

**Fig. 5** The boundary and form of the coastline profile

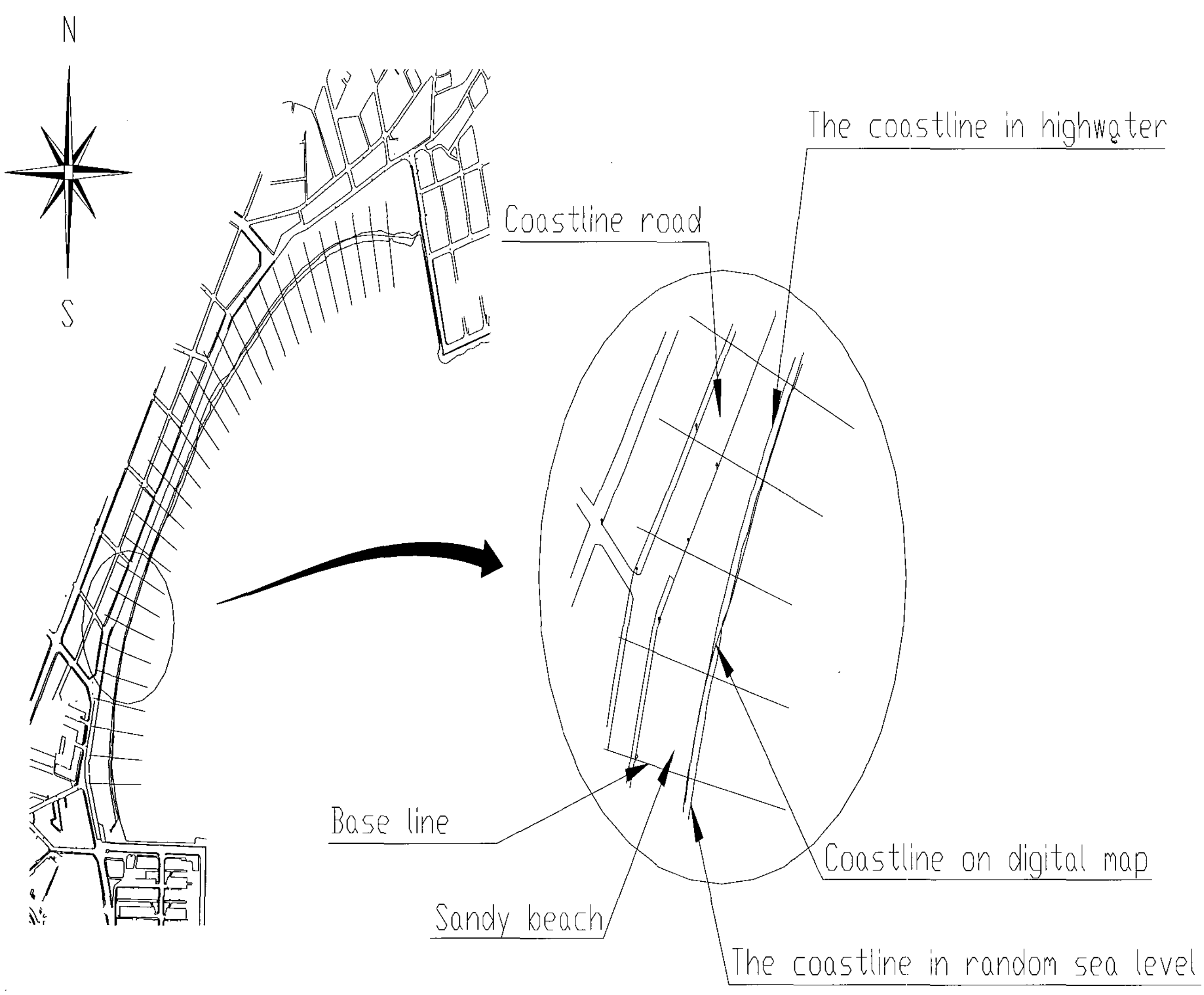


**Fig. 7** Digital map of the coastline

As shown in Table 6, the coastal slope was gentle between 2°03′ and 8°39′ to the reference lines, and the difference between the complemented length by height of the tide and the surveyed length was 0.15m ~0.53m, and its average was 0.34m. It satisfied ±0.70m, which comes from the positioning errors for each reduced scale published by the National Geography Institute.

Table 7 shows the distances between the coastlines in the digital map, and average sea level. For height of the tide 1.28m, there has been erosion from -0.08m to -12.16m, and accumulation from +1.86m to 8.16m. Distances between the coastlines in the digital map and average sea level show that there has been erosionfrom -0.41m to -6.63m, and accumulation from +0.76m to +14.04m. This means that there has been accumulation on the east and north side, and erosion on the south and west side.

**Table 6** The observation data

| Station | Coastline length($d$) | Height of the tide(Survey tide:$h$) | tide range | Coast slope($\Theta$) | Randomle selected height of the tide(tide range) | The complemented length with tide range(m) | Survey length(m) | Difference |
|---|---|---|---|---|---|---|---|---|
| 1 | 5.58 | 1.28(0.77) | 0.51 | 5°13′20″ | 1.07(0.21) | 2.30 | 2.75 | 0.45 |
| 2 | 4.65 | 1.28(0.77) | 0.51 | 6°15′33″ | 1.06(0.22) | 2.01 | 2.33 | 0.32 |
| 3 | 5.47 | 1.27(0.76) | 0.51 | 5°19′36″ | 1.06(0.21) | 2.25 | 2.67 | 0.42 |
| 4 | 5.88 | 1.27(0.76) | 0.51 | 4°57′26″ | 1.05(0.22) | 2.54 | 2.95 | 0.41 |
| 5 | 4.93 | 1.27(0.75) | 0.52 | 6°01′16″ | 1.04(0.23) | 2.18 | 2.56 | 0.38 |
| 6 | 3.42 | 1.27(0.75) | 0.52 | 8°38′44″ | 1.04(0.23) | 1.51 | 1.72 | 0.21 |
| 7 | 4.89 | 1.26(0.74) | 0.52 | 6°04′12″ | 1.03(0.23) | 2.16 | 2.41 | 0.25 |
| 8 | 4.93 | 1.26(0.74) | 0.52 | 6°01′16″ | 1.03(0.23) | 2.18 | 2.40 | 0.22 |
| 9 | 5.10 | 1.26(0.73) | 0.53 | 5°55′59″ | 1.02(0.24) | 2.31 | 2.69 | 0.38 |
| 10 | 5.02 | 1.26(0.73) | 0.53 | 6°01′37″ | 1.02(0.24) | 2.27 | 2.60 | 0.33 |
| 11 | 5.69 | 1.26(0.72) | 0.54 | 5°25′17″ | 1.01(0.25) | 2.63 | 3.01 | 0.38 |
| 12 | 5.42 | 1.26(0.72) | 0.54 | 5°41′23″ | 1.01(0.25) | 2.51 | 2.86 | 0.35 |
| 13 | 5.23 | 1.25(0.71) | 0.54 | 5°53′42″ | 1.00(0.25) | 2.42 | 2.73 | 0.31 |
| 14 | 4.56 | 1.25(0.71) | 0.54 | 6°45′13″ | 1.00(0.25) | 2.11 | 2.30 | 0.19 |
| 15 | 5.84 | 1.24(0.70) | 0.54 | 5°16′58″ | 0.99(0.25) | 2.70 | 3.09 | 0.39 |
| 16 | 5.32 | 1.24(0.70) | 0.54 | 5°47′45″ | 0.99(0.25) | 2.46 | 2.71 | 0.25 |
| 17 | 5.62 | 1.24(0.69) | 0.55 | 5°35′22″ | 0.98(0.26) | 2.66 | 2.88 | 0.22 |
| 18 | 4.37 | 1.23(0.69) | 0.54 | 7°02′40″ | 0.98(0.25) | 2.02 | 2.21 | 0.19 |
| 19 | 7.88 | 1.23(0.68) | 0.55 | 3°59′33″ | 0.97(0.26) | 3.73 | 4.18 | 0.45 |
| 20 | 6.23 | 1.23(0.68) | 0.55 | 5°02′42″ | 0.97(0.26) | 2.95 | 3.33 | 0.38 |
| 21 | 7.56 | 1.22(0.68) | 0.54 | 4°05′08″ | 0.96(0.26) | 3.64 | 4.16 | 0.52 |
| 22 | 6.51 | 1.22(0.68) | 0.54 | 4°44′30″ | 0.96(0.26) | 3.13 | 3.59 | 0.46 |
| 23 | 5.76 | 1.21(0.67) | 0.54 | 5°21′21″ | 0.96(0.26) | 2.67 | 2.91 | 0.24 |
| 24 | 7.09 | 1.21(0.67) | 0.54 | 4°21′20″ | 0.95(0.26) | 3.41 | 3.79 | 0.38 |
| 25 | 7.51 | 1.21(0.66) | 0.55 | 4°11′19″ | 0.95(0.26) | 3.55 | 4.08 | 0.53 |
| 26 | 10.56 | 1.20(0.66) | 0.54 | 2°55′38″ | 0.95(0.26) | 4.89 | 5.29 | 0.40 |
| 27 | 10.28 | 1.20(0.65) | 0.55 | 3°03′45″ | 0.94(0.26) | 4.86 | 5.29 | 0.43 |
| 28 | 13.47 | 1.20(0.65) | 0.55 | 2°20′17″ | 0.94(0.26) | 6.37 | 6.59 | 0.22 |
| 29 | 15.36 | 1.19(0.64) | 0.55 | 2°03′03″ | 0.93(0.26) | 7.26 | 7.72 | 0.46 |
| 30 | 12.75 | 1.19(0.64) | 0.55 | 2°28′12″ | 0.93(0.26) | 6.03 | 6.18 | 0.15 |
| Average | | | | | | | | 0.34 |

**Table 7** The differences of length between coastline on a digital map and the m. a. s. l.(-:erosion, +:accumulation)

| Station | The differences between coastline in a digital map of height of the tide 1.28m and the m.a.s.l(m) | Coast slope($\Theta$) | At mean sea level of 0.649m, coastline distance(0.571m)(m) | The differences between coastline in a digital map and the m.a.s.l(m) |
|---|---|---|---|---|
| 1 | -10.22 | 5°13′20″ | 6.25 | -3.97 |
| 2 | -7.89 | 6°15′33″ | 5.21 | -2.68 |
| 3 | -6.53 | 5°19′36″ | 6.12 | -0.41 |
| 4 | -3.26 | 4°57′26″ | 6.58 | +3.32 |
| 5 | -0.27 | 6°01′16″ | 5.41 | +5.14 |
| 6 | -0.08 | 8°38′44″ | 3.76 | +3.68 |
| 7 | -4.61 | 6°04′12″ | 5.37 | +0.76 |
| 8 | -4.13 | 6°01′16″ | 5.41 | +1.28 |
| 9 | -4.09 | 5°55′59″ | 5.49 | +1.40 |
| 10 | -2.86 | 6°01′37″ | 5.41 | +2.55 |
| 11 | -3.25 | 5°25′17″ | 6.02 | +2.77 |
| 12 | -8.41 | 5°41′23″ | 5.73 | -2.68 |
| 13 | -12.16 | 5°53′42″ | 5.53 | -6.63 |
| 14 | -10.46 | 6°45′13″ | 4.82 | -5.64 |
| 15 | -9.19 | 5°16′58″ | 6.18 | -3.01 |
| 16 | +5.27 | 5°47′45″ | 5.63 | +10.9 |
| 17 | +6.25 | 5°35′22″ | 5.83 | +12.08 |
| 18 | +8.16 | 7°02′40″ | 4.62 | +12.78 |
| 19 | -0.99 | 3°59′33″ | 8.18 | +7.19 |
| 20 | +3.47 | 5°02′42″ | 6.47 | +9.94 |
| 21 | +3.63 | 4°05′08″ | 7.99 | +11.62 |
| 22 | +3.45 | 4°44′30″ | 6.88 | +10.33 |
| 23 | +5.64 | 5°21′21″ | 6.09 | +11.73 |
| 24 | +4.22 | 4°21′20″ | 7.50 | +11.72 |
| 25 | +4.86 | 4°11′19″ | 7.80 | +12.66 |
| 26 | +2.87 | 2°55′38″ | 11.17 | +14.04 |
| 27 | +1.86 | 3°03′45″ | 10.67 | +12.53 |
| 28 | -1.01 | 2°20′17″ | 13.99 | +12.98 |
| 29 | -4.55 | 2°03′03″ | 15.95 | +11.4 |
| 30 | -3.86 | 2°28′12″ | 13.24 | +9.38 |

## 5. Conclusions

Based on the coastline surveyed using real time kinematics GPS/GLONASS during high wave of scar, randomly surveyed coastlines were converted to the lengths of coastlines by tides. The results are outlined below:

(1) When the coastline was surveyed using real time Kinematics GPS/GLONASS, its average error was 0.43m, and satisfied the tolerance ±0.70m of the positioning errors for each reduced scale published by the National Geography Institute.

(2) When the surveying results using real time kinematics GPS/GLONASS were compared to the coastlines on a digital map, erosions were found. It may be possible to monitor diminishing of the beach area, due to loss of sands in real time.

(3) With real time kinematics GPS/GLONASS, the boundaries of coastlines, which can be changed by complementing digital terrain models or sea level rises, can be extracted in real time more easily than normal methods.

## References

Http://www.knto.or.kr/Korean/index.html

Hydrographic Work Guides, (1980). Ministry of Transportation & Hydrographic Office.

Intergovernmental Panel on Climate Change (IPCC), (1990). Climate Change: the IPCC Scientific Assessment, J.T. Houghton, G.J. Jenkins and J.J Ephraums (eds.), Cambridge University Press, Cambridge, UK.

Jang, H.S., and Seo, D.J. and Lee, J.C. (2003). "Determination of Coastline by he GPS/GLONSS Combination Method", Journal of Korean Society of Civil Engineers, Vol 23, No 3D, pp 385-391.

Kim, G.H. (2000). General GIS (2nd edition), Deyoungsa, p. 81

Kim, H.Y. and Choi,. C.U. (2005). "Research for a Long-term Topographic Change in the Region of Kwoanganri ", Journal of Korean Society of Civil Engineers, Vol 25, No 1D, pp 203-211.

Lee, S.W. and Kum, G.S. (1996). Ocean Surveying,. pp 149-158.

Park, K.W. (2001). "A Study on Changing Coastlines of Kwanganri using Aero photogrammetry", Proceedings of the 2001 KSRS Spring Meeting, pp 122-127.

Yang, I.T. (1990). "A Study on the Shoreline Changes by the Geodetic Characteristics of the East Sea and on the Numerical Model for the predicting", Korea Science and Engineering Foundation, pp 17-32.

Yeu, B.M. (1995). The Principles of Surveying (II), pp 284-291.

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